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processes separate from those that affect basic stimulus encoding.

[478] Frequency-Modulation Vowel Maps in Normal-Hearing and Hearing-Impaired Listeners

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Background

Human singing voices are not steady in pitch but typically contain coherent frequency fluctuations over time. The perception of natural voice vibrato thus relies on the presence of coherent frequency modulation (CFM). Sensorineural hearing loss is known to affect the ability to detect changes in frequency, presumably leading to degraded voice perception. This study investigated the ability of normal-hearing (NH) and hearing-impaired (HI) listeners to perceive a sung vowel by adding CFM to a steady complex tone. The aim was to determine the extent of the “vowel map” along the FM-rate and FM-excursion dimensions in NH listeners, and whether this area for FM-based singing-voice perception is affected by hearing impairment.

Methods

The ranges of CFM rates and excursions leading to voice formation were determined in a group of NH listeners and a group of HI listeners with moderate to severe sensorineural hearing loss. The listeners adjusted either the FM rate or the FM excursion applied to the synthesized vowel /oh/ in an adaptive “yes/no” procedure, while the other FM parameter remained fixed. In each presentation, the listeners were asked to judge whether the sound corresponded to a natural singing voice. The lower and upper FM-excursion thresholds were determined for fixed FM-rates between 3 and 8 Hz, and the lower and upper FM-rate thresholds for fixed FM-excursions between 21 and 91 cents.

Results

In NH listeners, adding CFM to an unmodulated complex tone was sufficient to evoke the perception of a singing voice for FM rates between 4.3 and 7.4 Hz and FM excursions between 15 and 64 cents on average. In contrast, HI listeners typically exhibited broader vowel maps than NH listeners, whereby their maps were shifted towards higher FM excursions and extended towards lower FM rates than those of NH listeners. The large across-subject variability in the HI group was not fully explained by the listeners’ audiograms or auditory-filter bandwidths at the vowel’s fundamental frequency.

Conclusion

Hearing loss was found to affect the formation of a sung vowel based on FM-rate and FM-excursion cues. It remains unclear to what extent this is attributable to deficits in FM detection or discrimination, reduced frequency selectivity, or difficulties in following the rate of

frequency changes. The vowel maps determined in NH listeners may provide reference values when constructing synthetic-vowel stimuli with realistic sung vibrato.

[479] The Ability of Hearing-Impaired Listeners to Use Temporal-Envelope Cues Recovered from Speech Frequency Modulation

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Background

Recent studies suggest that normal-hearing listeners maintain robust speech intelligibility despite severe degradations of amplitude-modulation (AM) cues, by using temporal-envelope information recovered from broadband frequency-modulation (FM) speech cues at the output of cochlear filters. This psychophysical study aimed to assess whether cochlear damage alters this capacity to reconstruct temporal-envelope information from FM.

Methods

This was achieved by measuring the ability of normal-hearing listeners and listeners with mild-to-moderate hearing loss to identify nonsense syllables processed to degrade AM cues while leaving FM cues intact within three broad frequency bands.

Results

Hearing-impaired listeners showed significantly poorer identification scores than normal-hearing listeners. However, the deficit shown by hearing-impaired listeners was relatively modest. Overall, hearing-impaired data and the results of simulation studies were consistent with a poorer-than-normal ability to reconstruct temporal-envelope information resulting from a broadening of cochlear filters by a factor ranging from 2 to 4.

Conclusion

These results indicate that temporal-envelope reconstruction from broadband FM is an important, early auditory mechanism contributing to the robust perception of speech sounds in degraded listening conditions. These results also suggest that most people suffering from mild to moderate cochlear hearing loss can make efficient use of reconstructed envelope cues despite degradations in frequency selectivity. Still, these results suggest that poorer-than-normal frequency selectivity impairs somewhat temporal-envelope reconstruction mechanisms.